

REDBACK: an Open-Source Highly Scalable Simulation Tool for Rock Mechanics with Dissipative Feedbacks

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MINERAL RESOURCES FLAGSHIP

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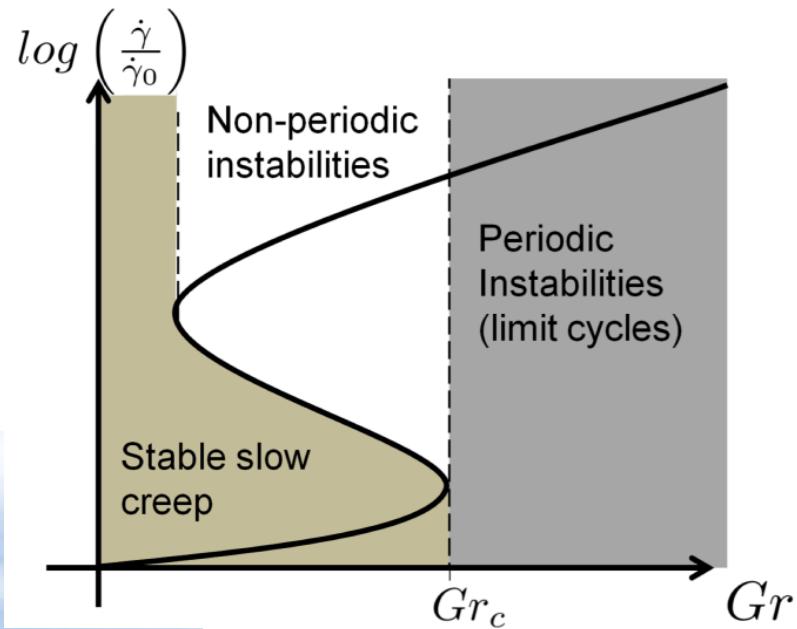
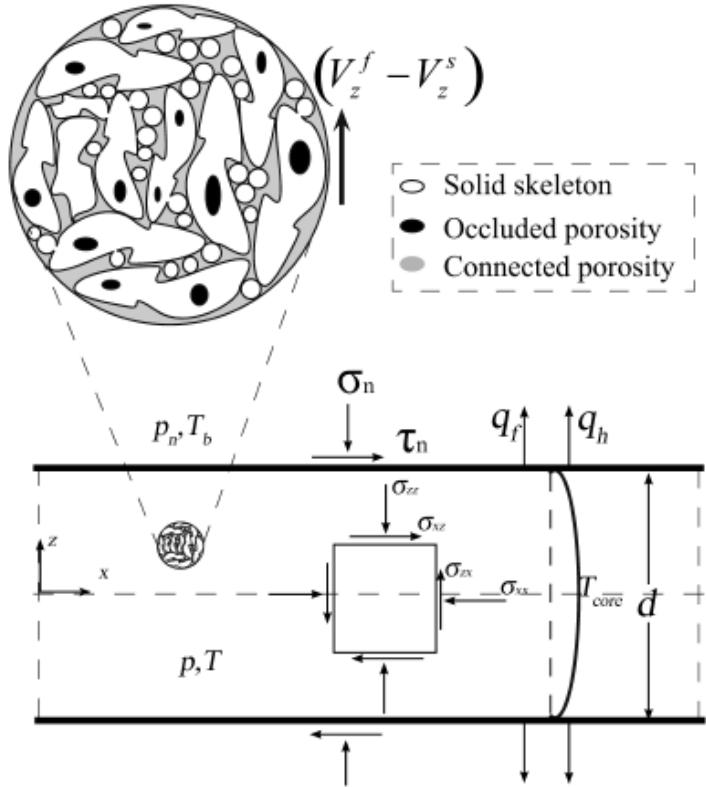
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THMC modelling of chemical shear zones



“S curve”

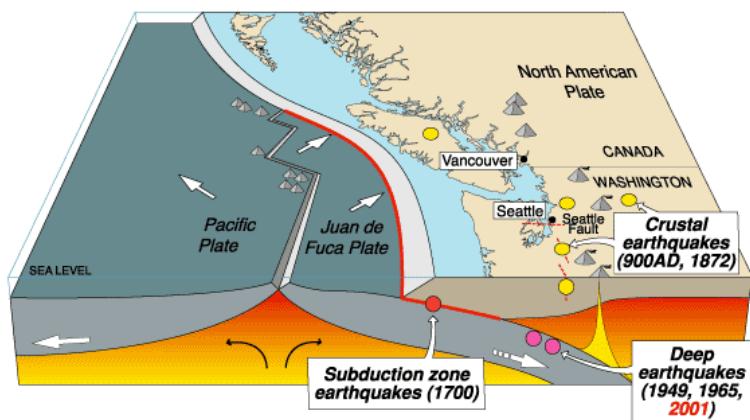
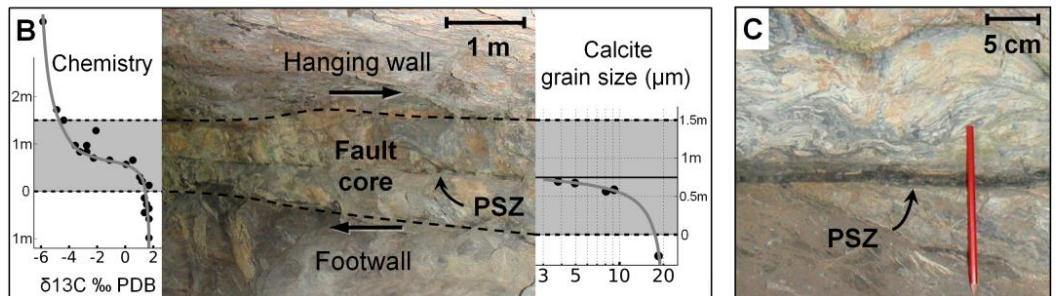
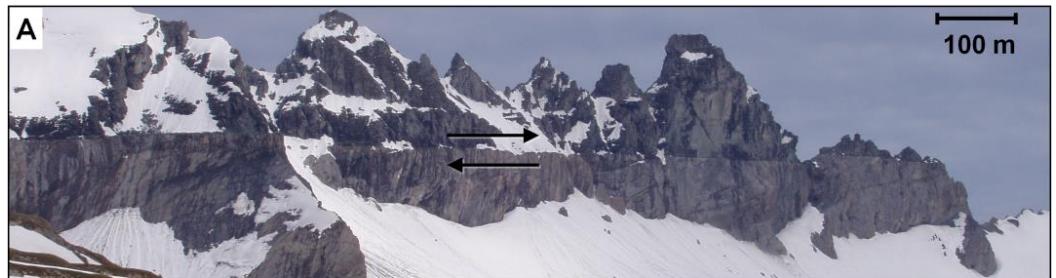
Geological instabilities

Alevizos et al 2014 – JGR part I

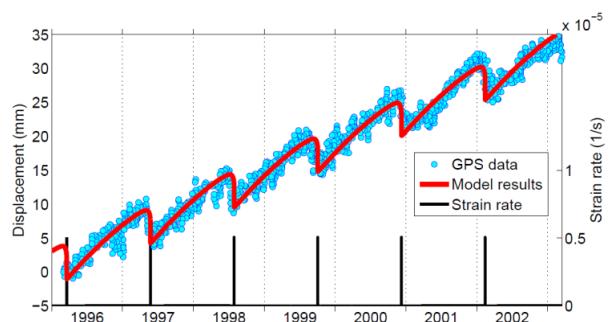
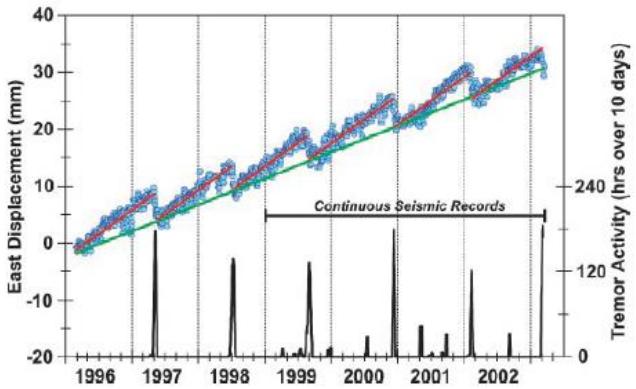
Veveakis et al 2014 – JGR part II

Poulet et al 2014 – JGR part III

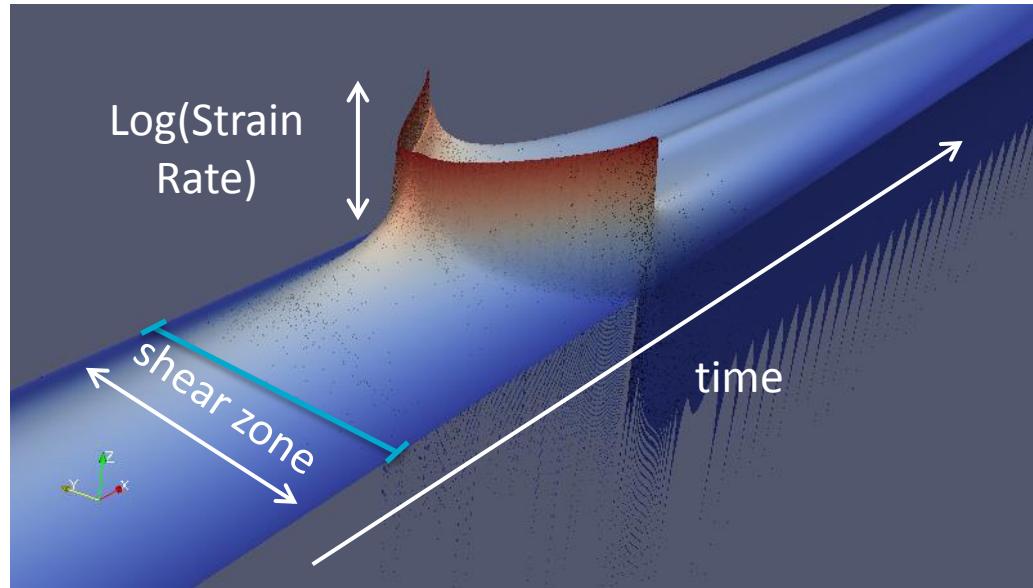
Poulet et al 2014 – GRL



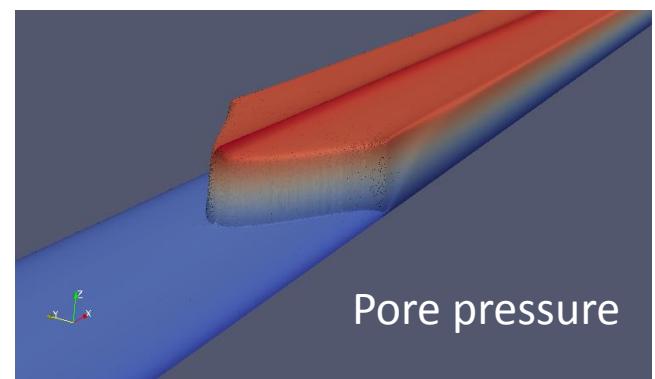
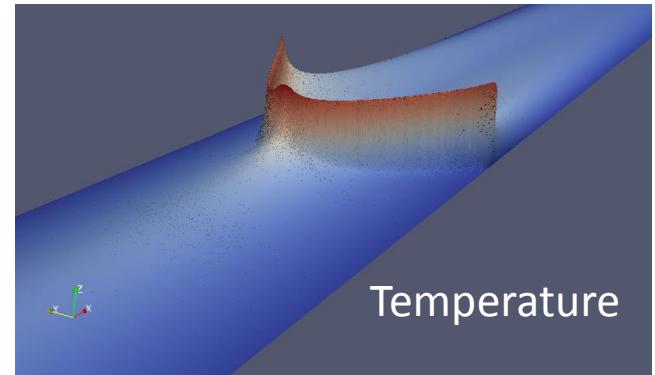
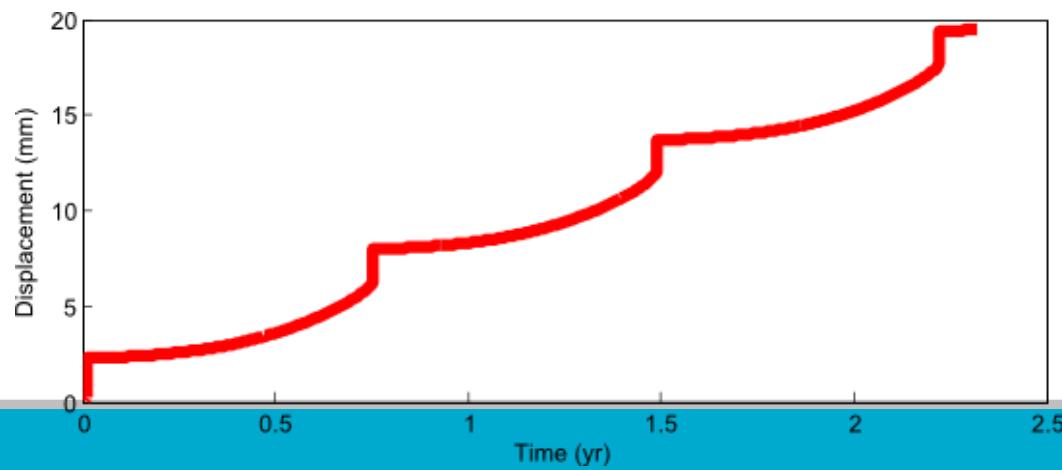
Rogers & Dragert 2003 – Science



THMC oscillator – initial numerical results



Integrate for displacement



- Already (too) hard in 1D
- Not practical in 2D
- Not feasible at all in 3D

Multiphysics Object-Oriented Simulation Environment (MOOSE)

<http://mooseframework.org>

Some of the capability at your fingertips:

- Fully-coupled, fully-implicit multiphysics solver
- Dimension independent physics
- Automatically parallel (largest runs >100,000 CPU cores!)
- Modular development simplifies code reuse
- Built-in mesh adaptivity
- Physics modules providing general capability for solid mechanics, phase field modeling, Navier-Stokes, heat conduction and more

Redback



an Open-Source Highly Scalable Simulation Tool for
Rock Mechanics with Dissipative Feedbacks

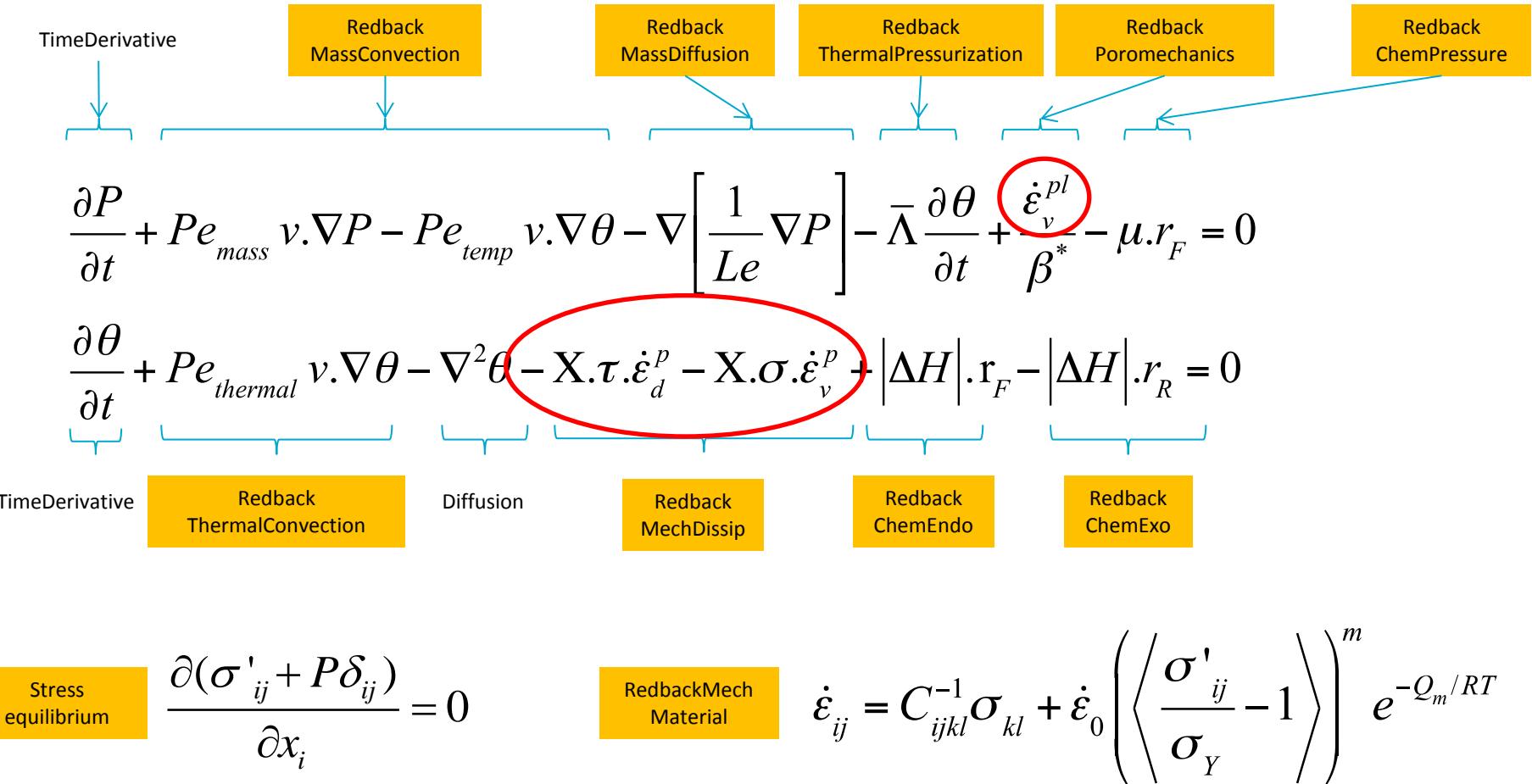
<https://github.com/pou036/redback>

- Mechanics (elasto-visco-plasticity using overstress plasticity)
 - Thermal processes (diffusion, advection, shear heating, latent heat)
 - Fluid flow in fully saturated porous medium (Darcy)
 - Chemical reaction of type $AB_{(solid)} \xrightleftharpoons[r_R]{r_F} A_{(solid)} + B_{(fluid)}$
 - Porosity (and permeability) evolution - chemical damage
-
- Current focus on understanding the (very rich) theoretical model and benchmarking against laboratory experiments
 - Dimensionless formulation

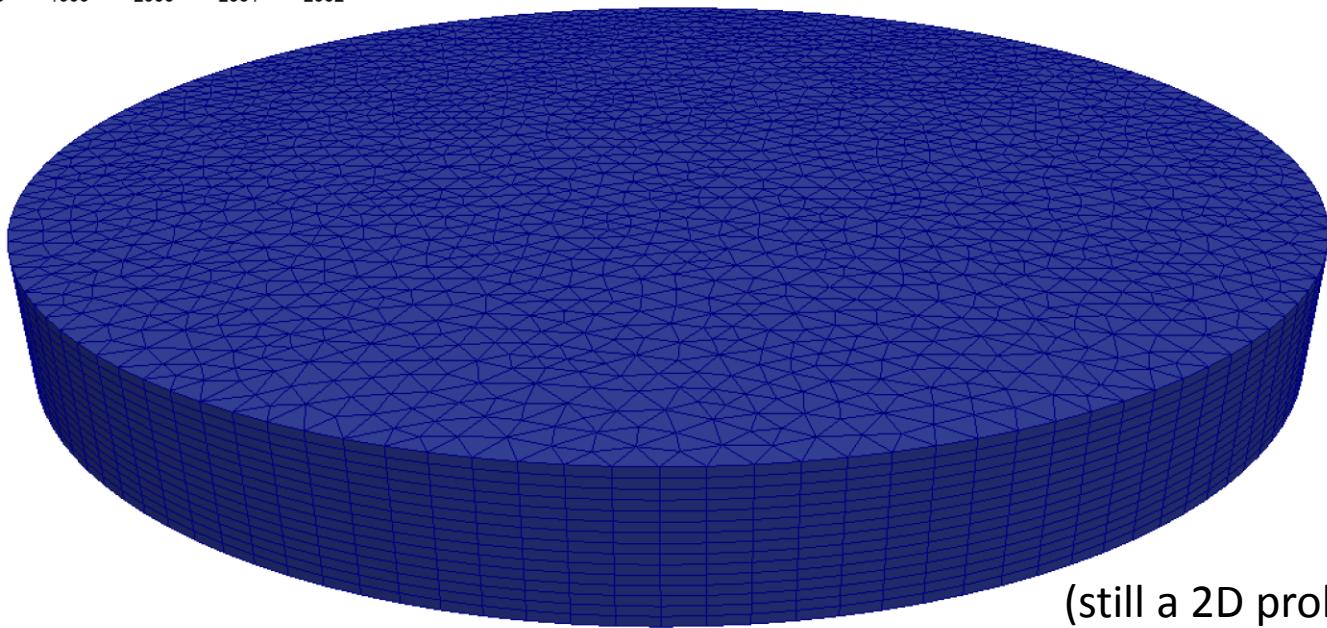
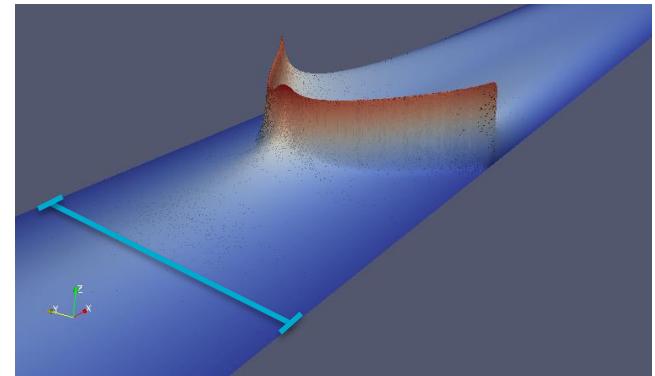
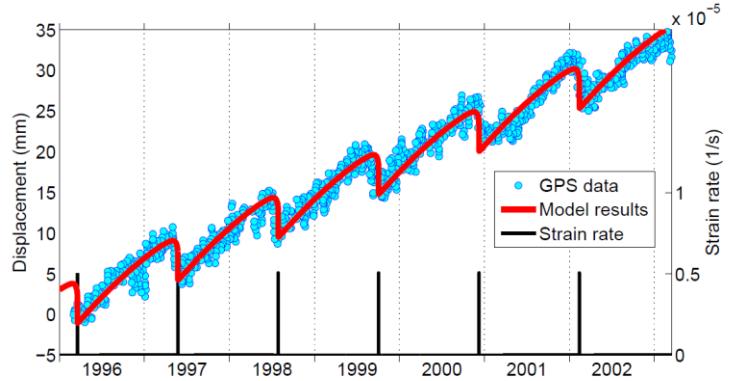
Localisation phenomena



System of equations – Redback kernels

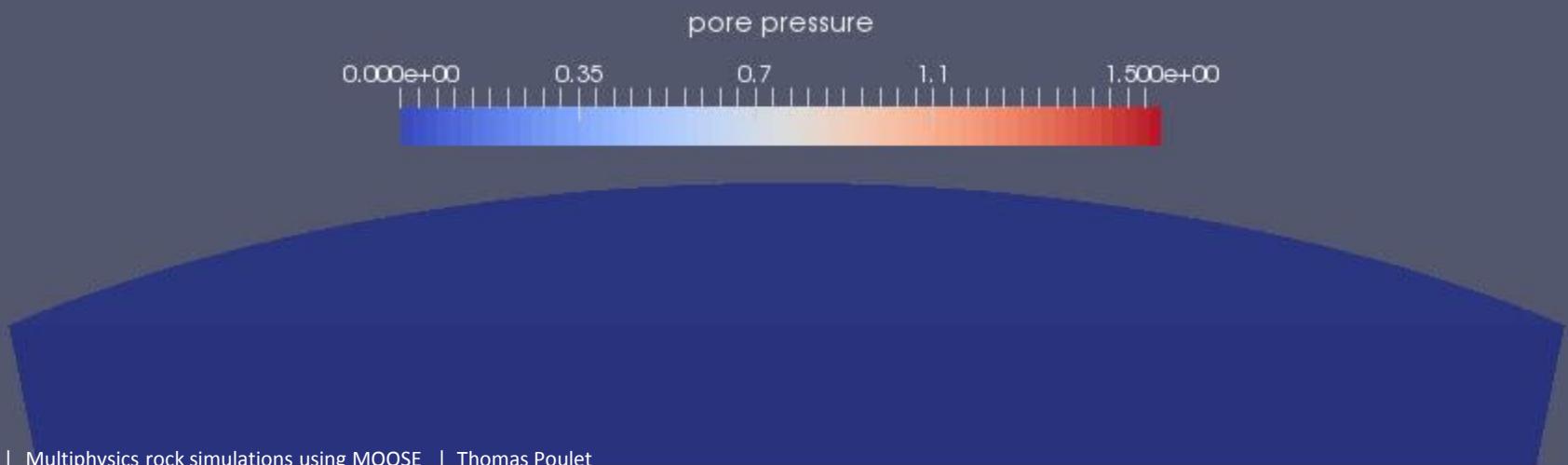
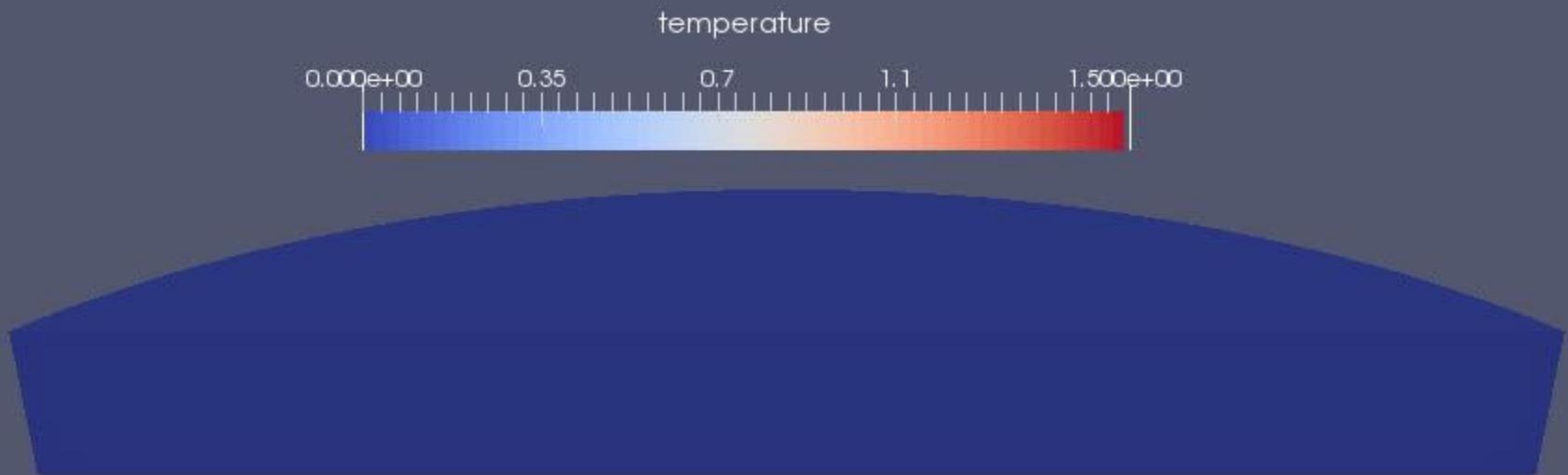


Chemical oscillator in 3D

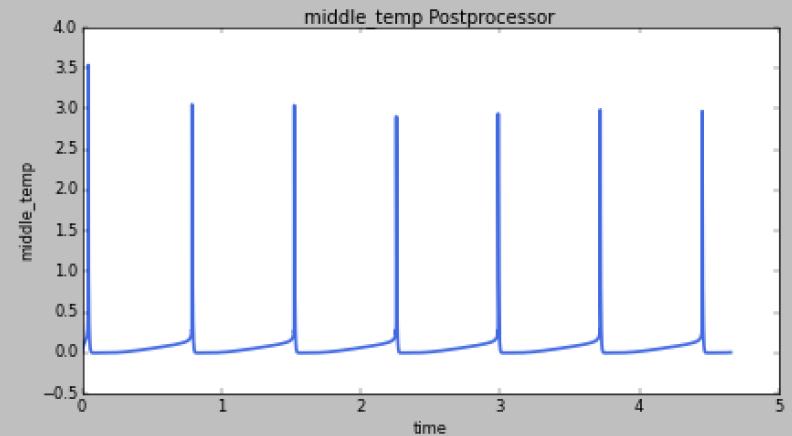
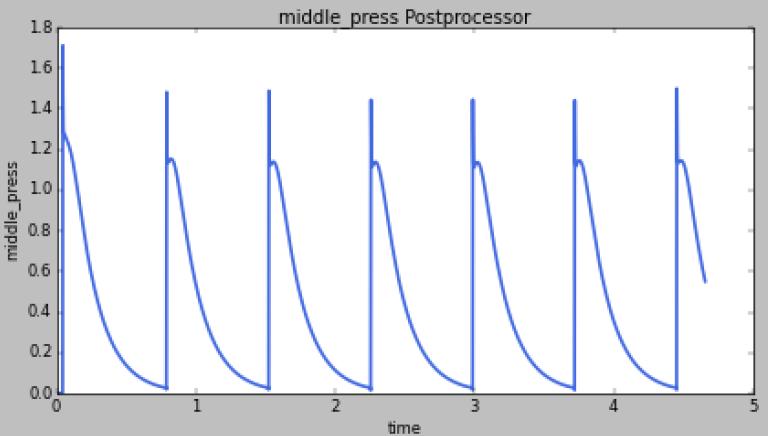
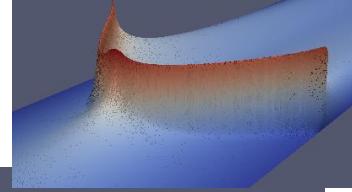


(still a 2D problem...)

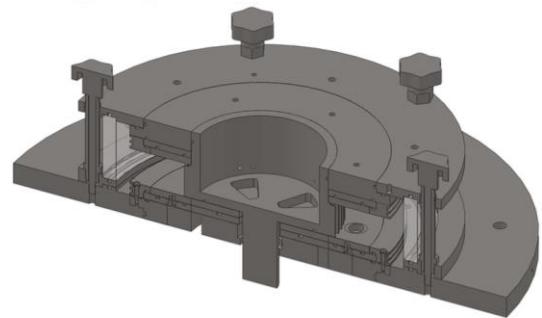
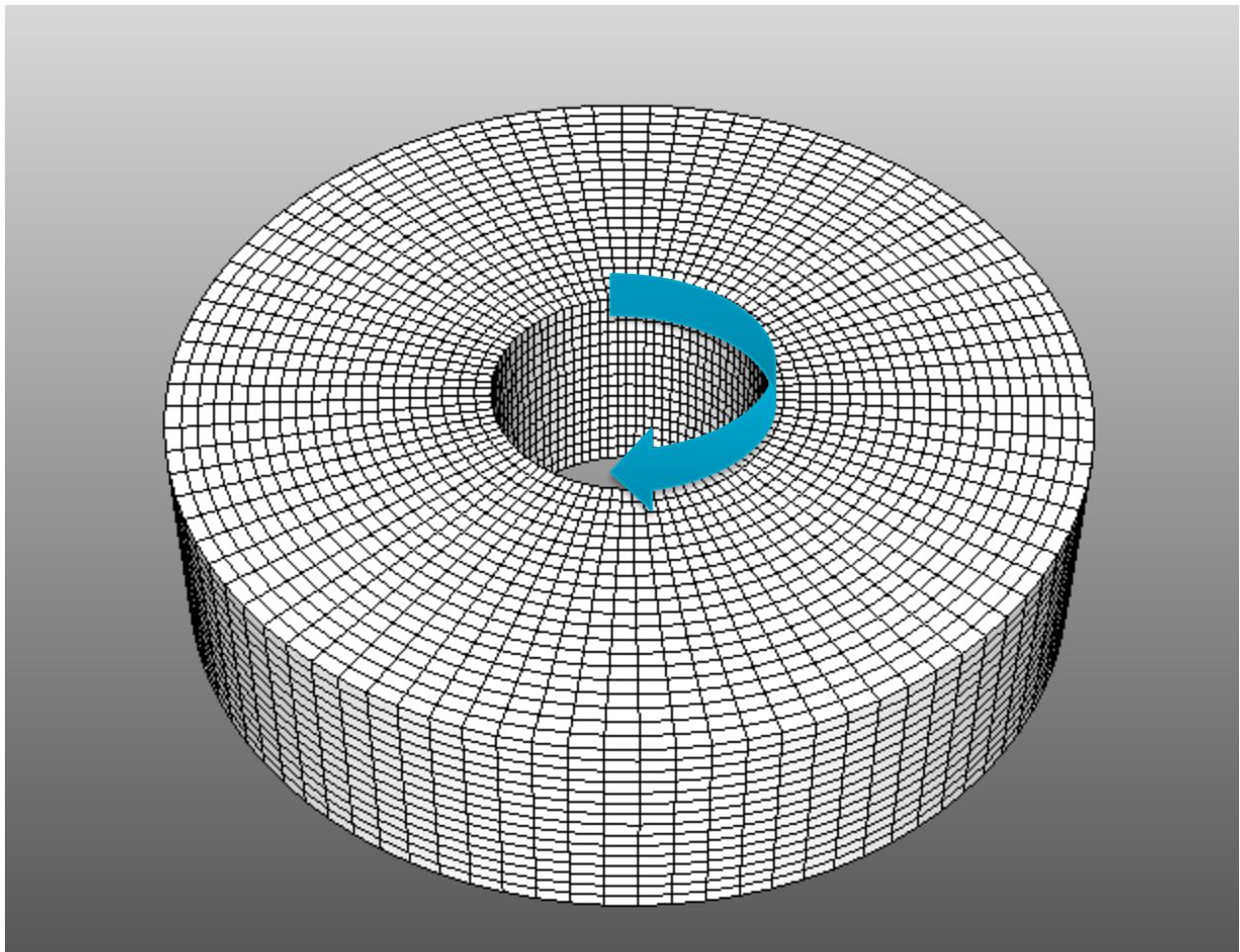
Chemical decomposition in 3D - results



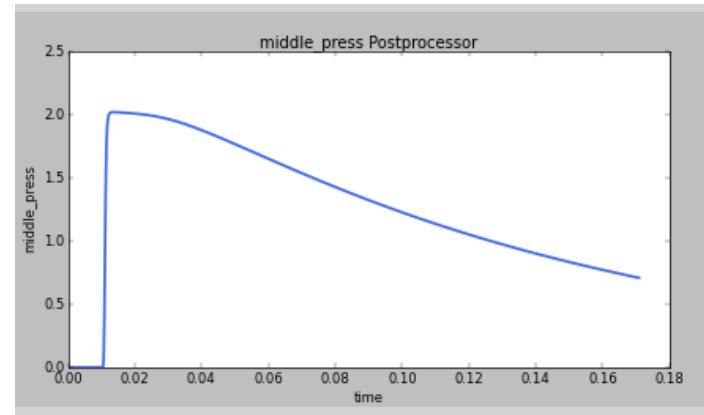
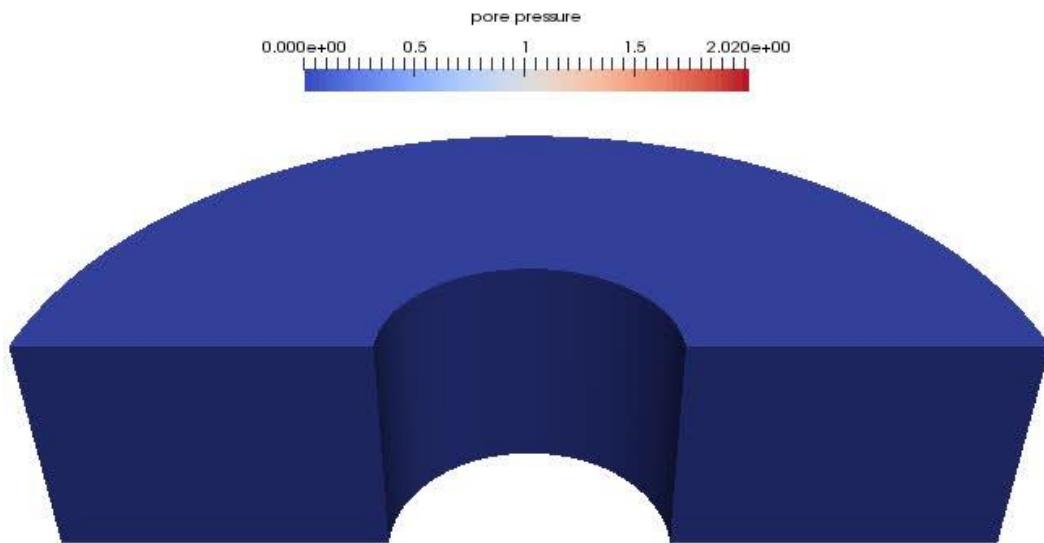
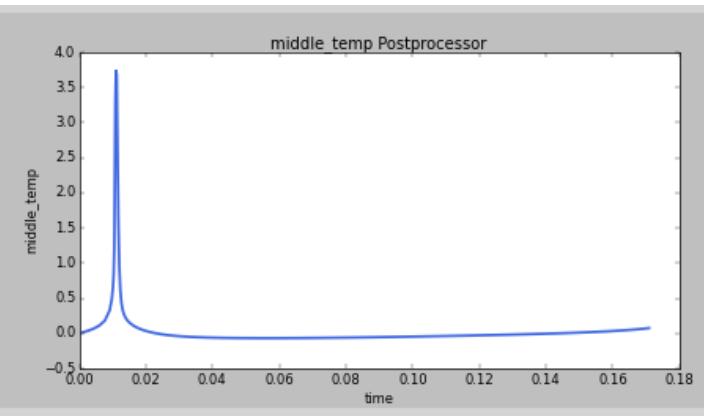
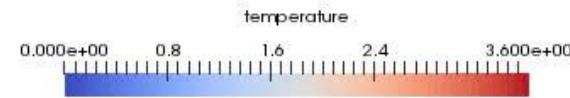
Zoom on the temperature peak



Ring shear experiment

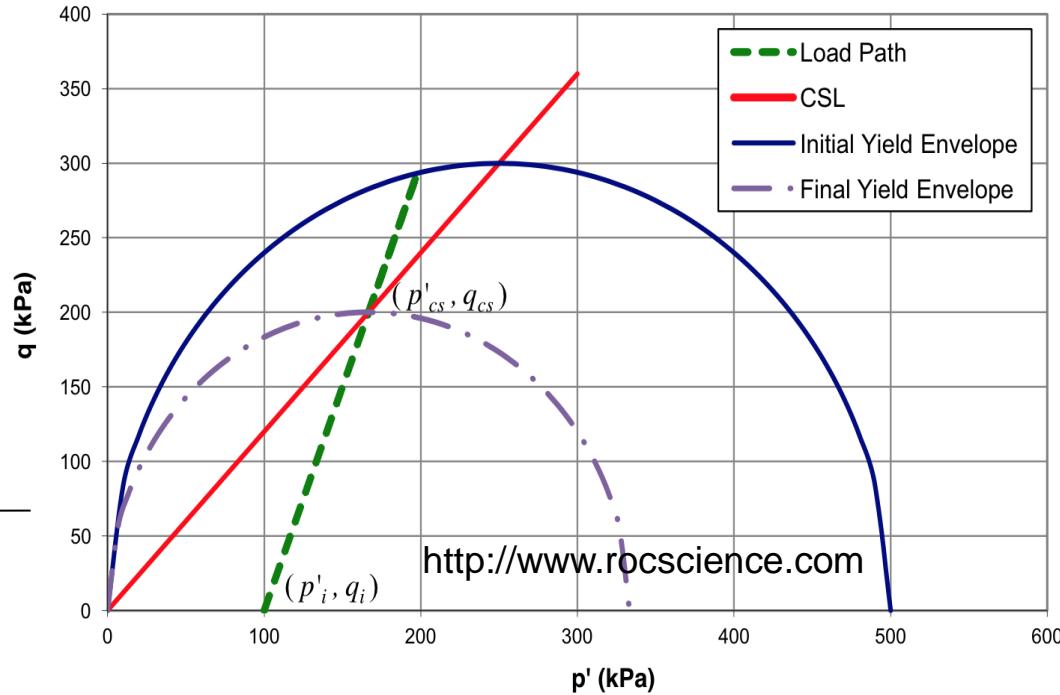
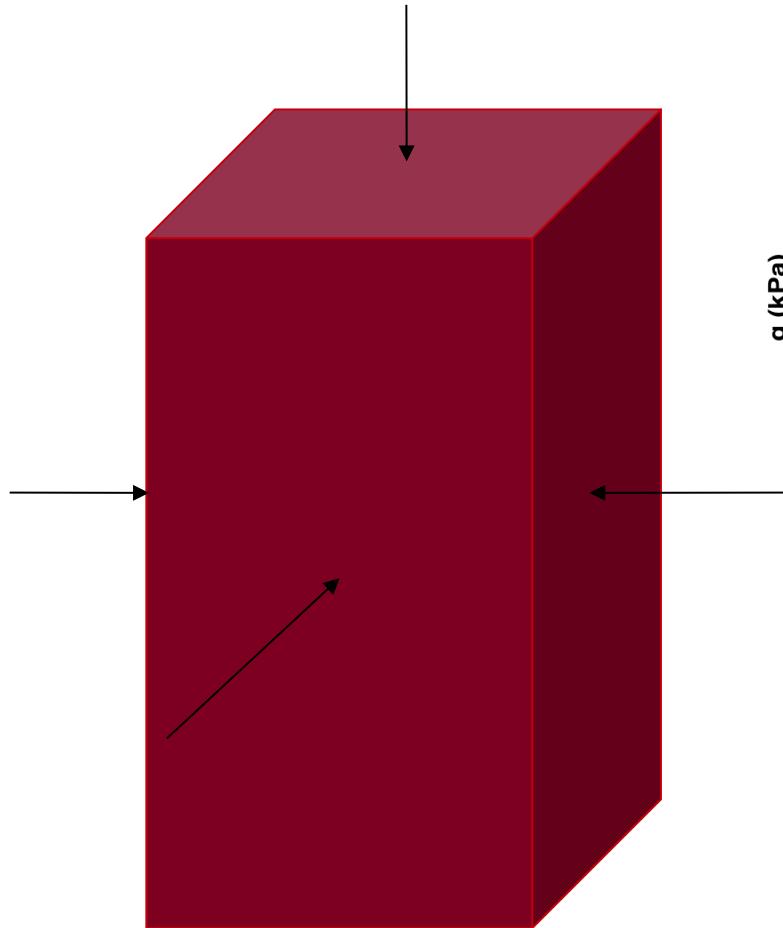


Ring shear results



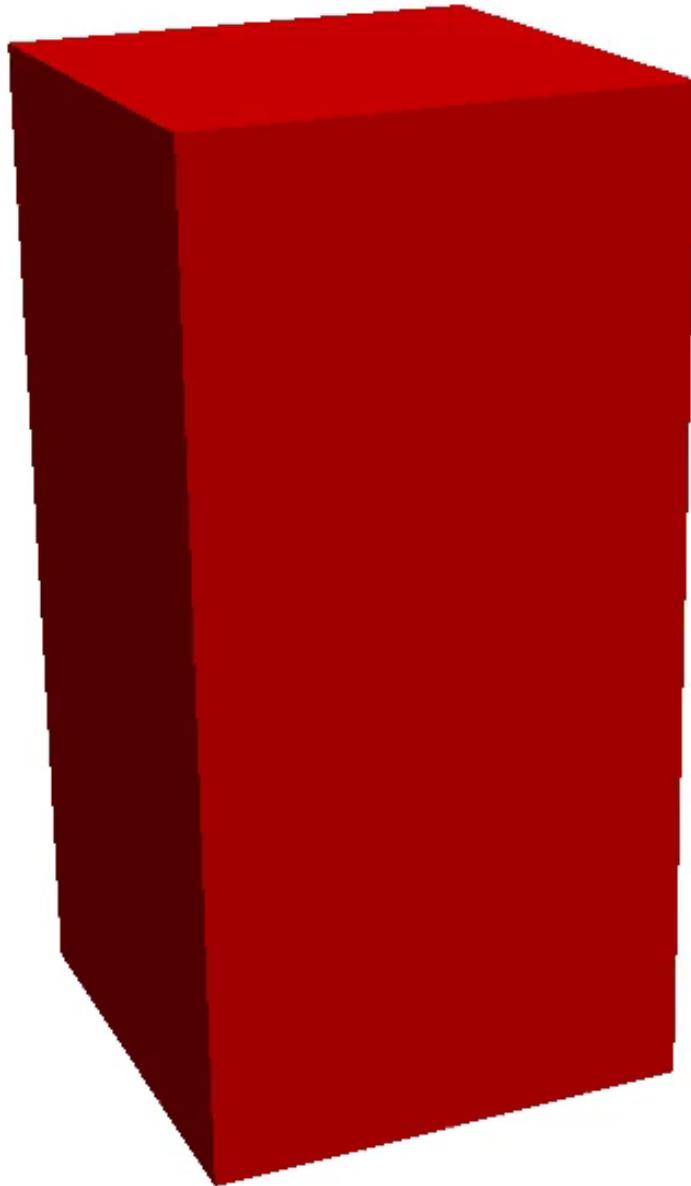
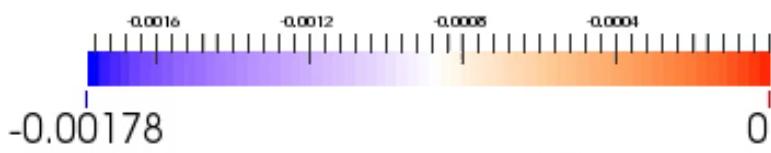
Adding mechanics

Triaxial experiments in clay-like materials

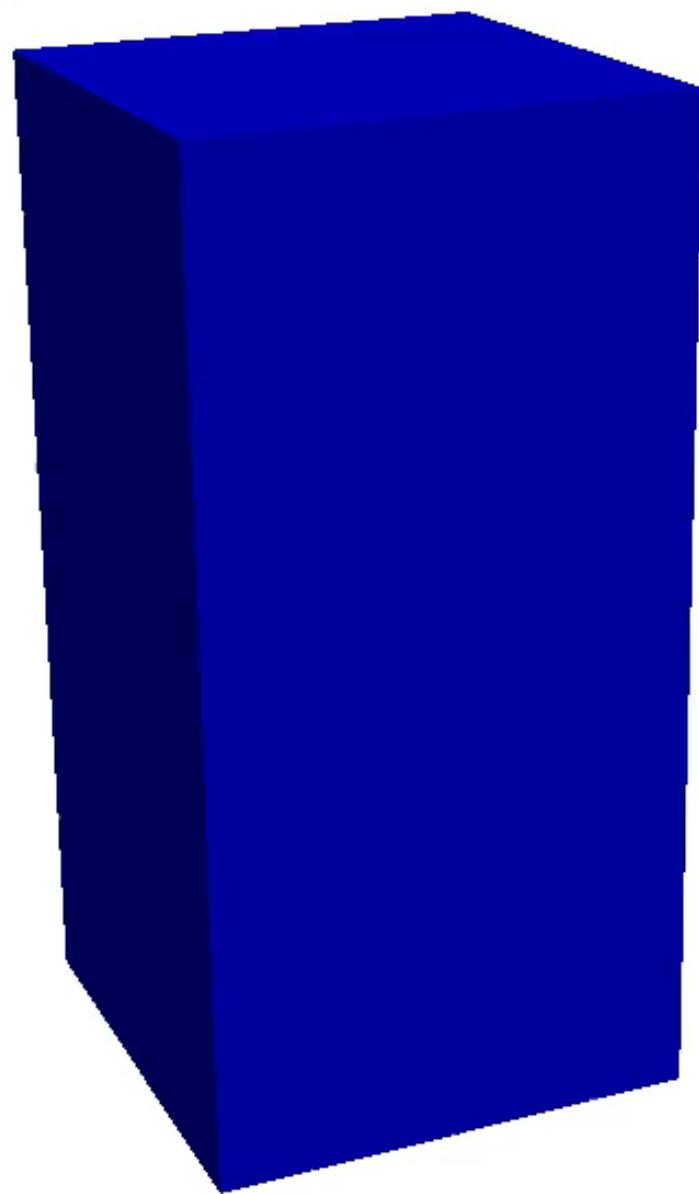
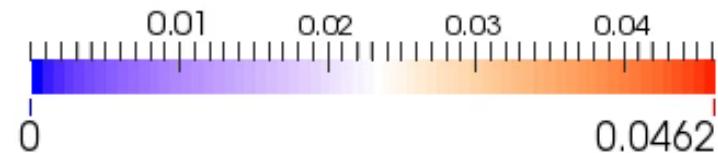


Drained triaxial compressive test on a highly over consolidated clay sample

Volumetric strain



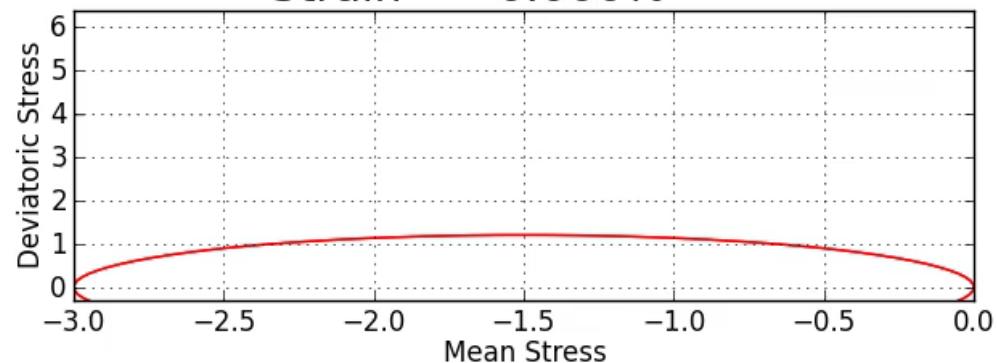
Mises strain



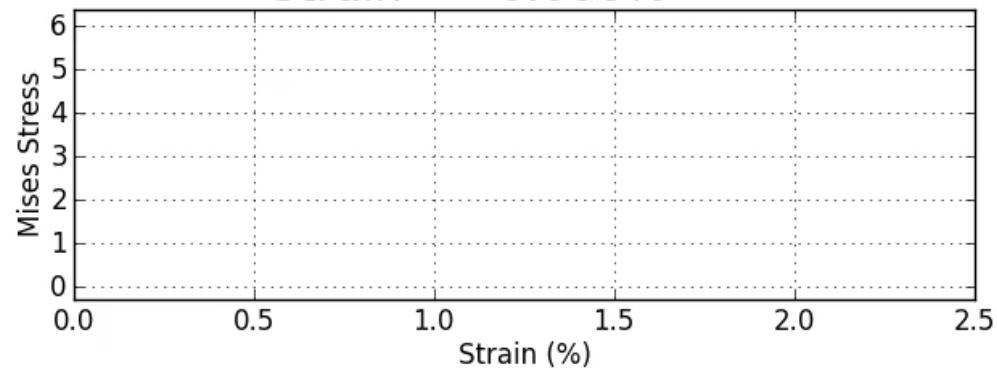
Volumetric strain



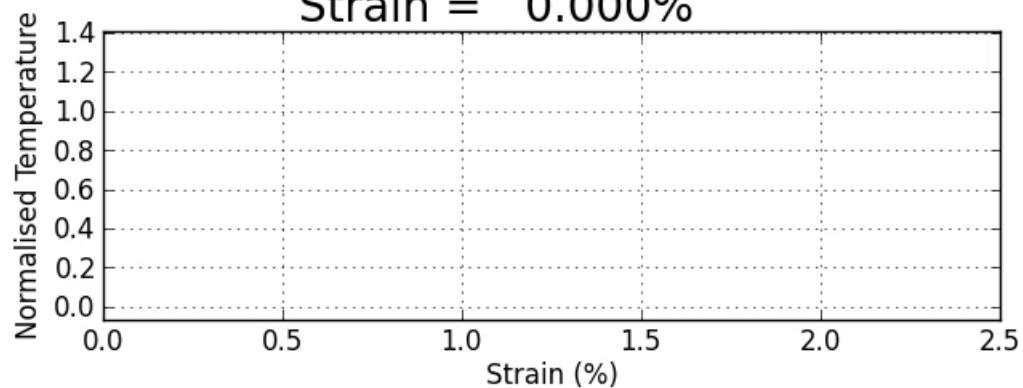
Strain = 0.000%



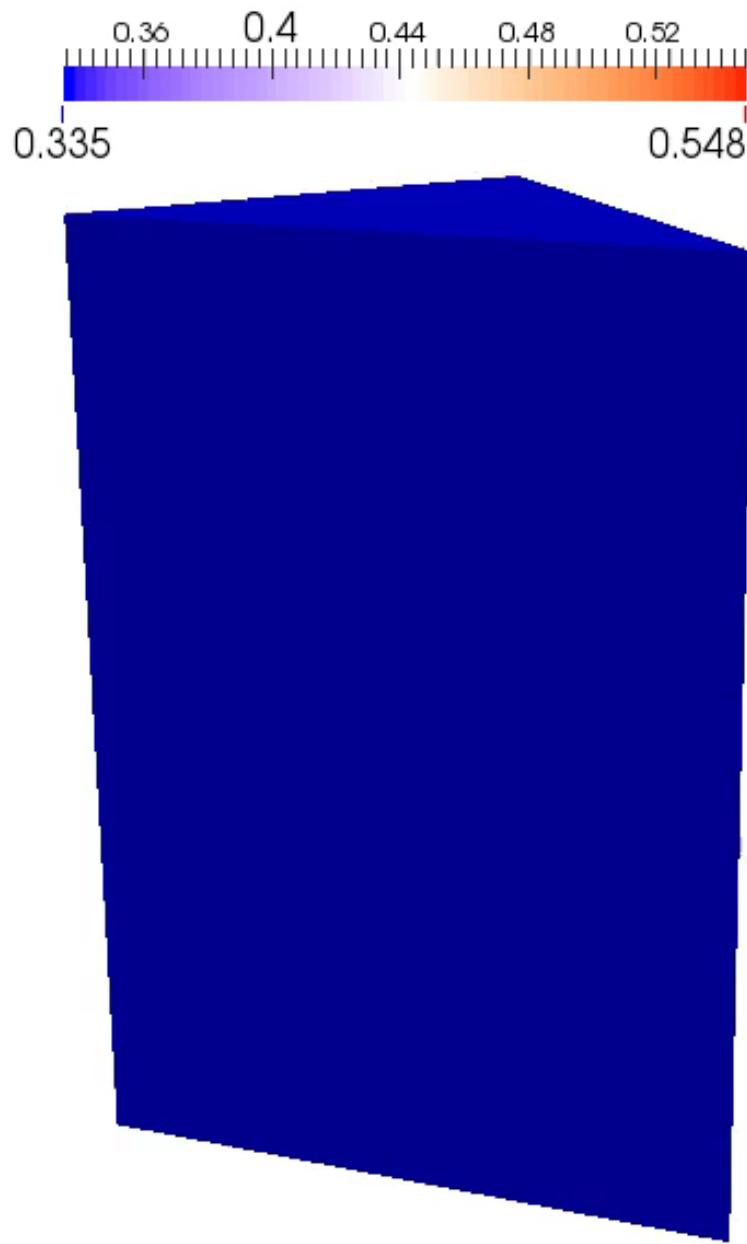
Strain = 0.000%



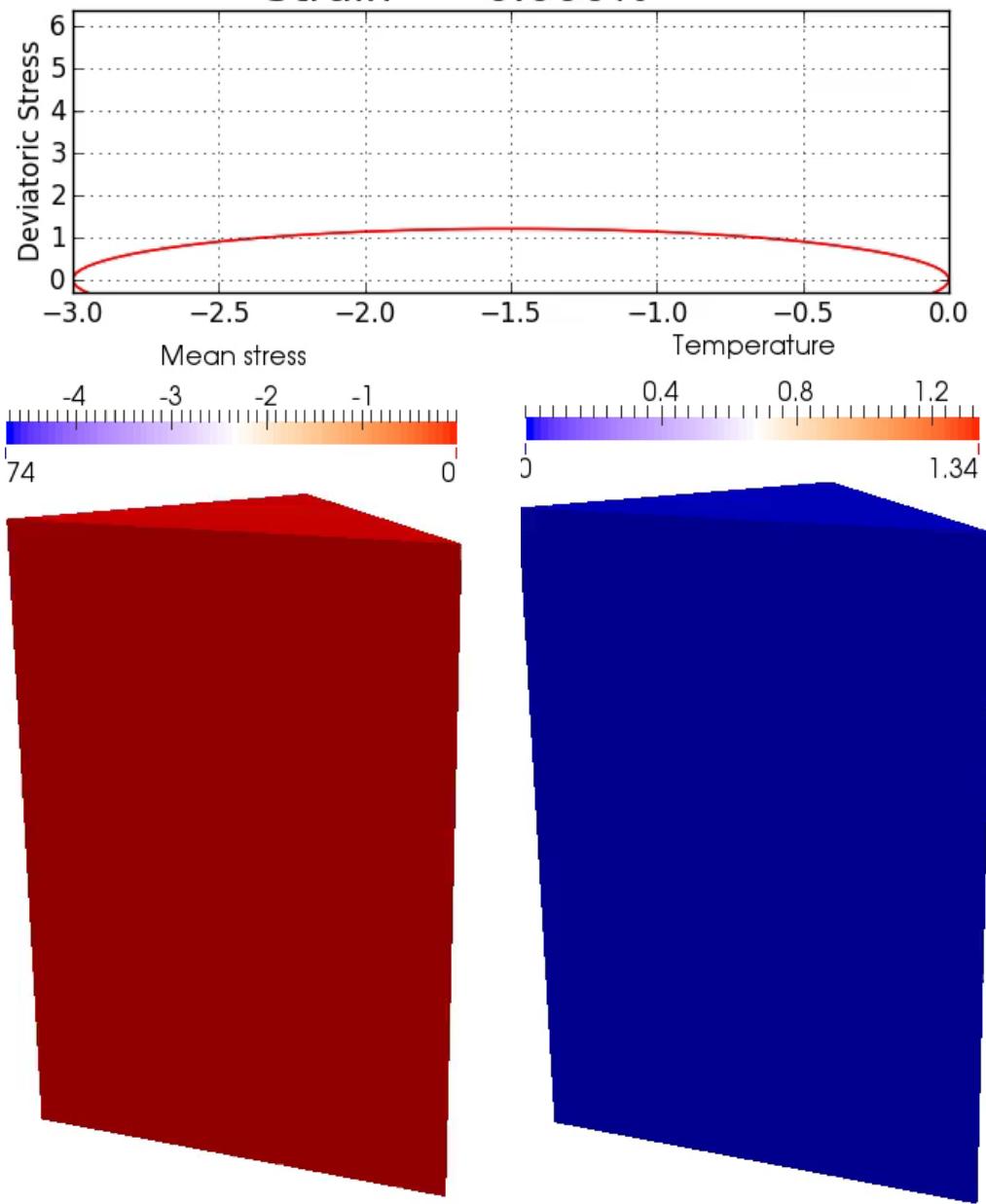
Strain = 0.000%



Porosity



Strain = 0.000%



Conclusions

- Multi-physics properly handled in 3D with tightly coupled solver
Redback proof-of-concept is there!
- MOOSE provides a powerful tool to
 - Prototype efficiently
 - Handle strong non-linearities
 - Scale on large supercomputers
- Calibration work still ahead...
- Step forward towards single model

<https://github.com/pou036/redback>



Thank you

CSIRO Mineral Resources Flagship

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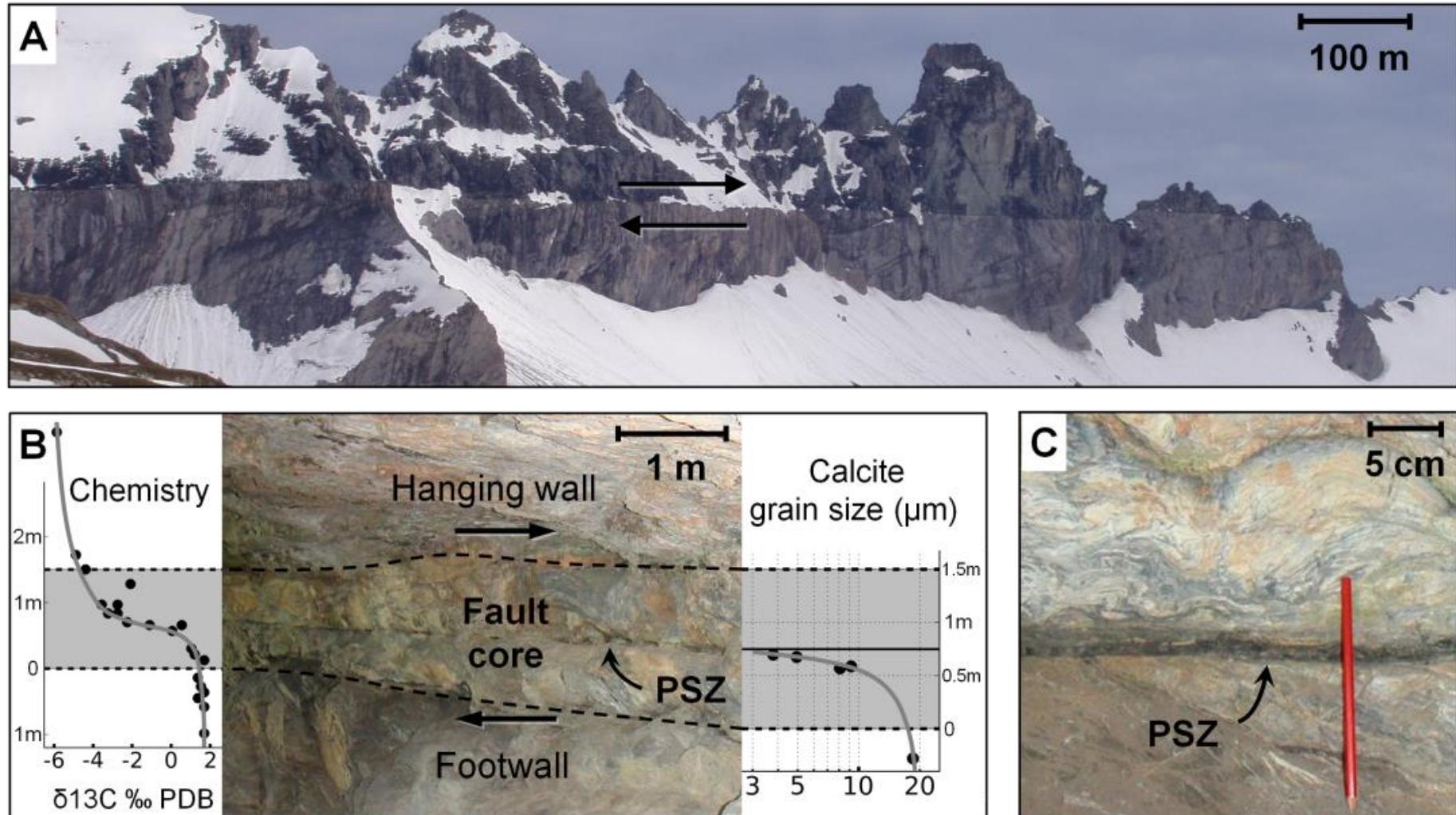
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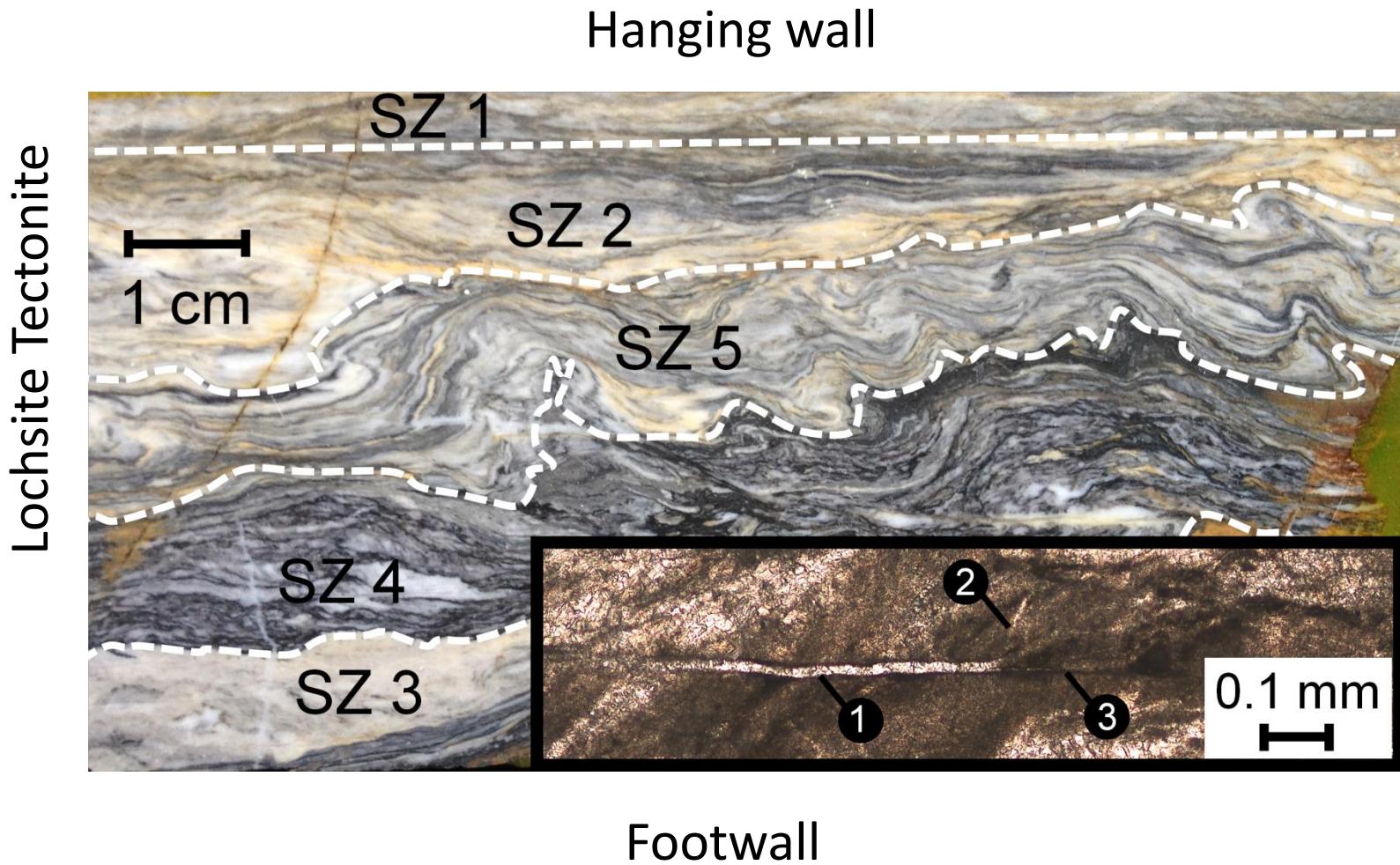
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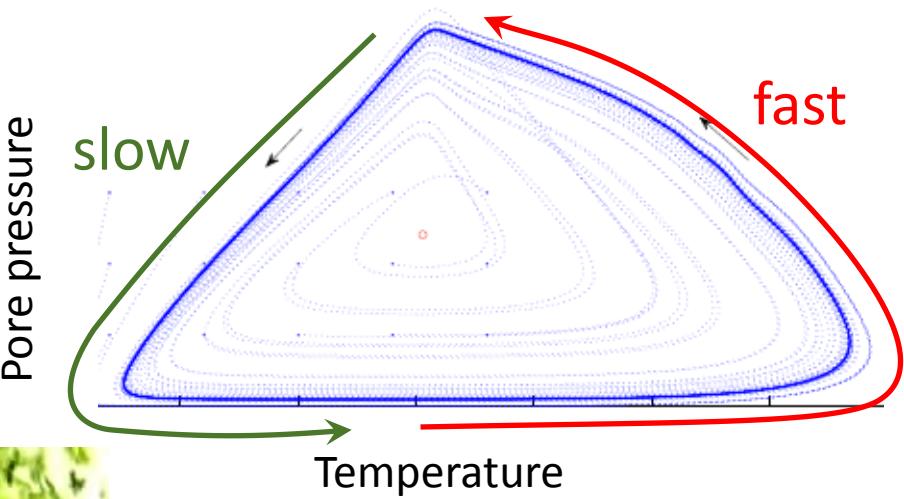
Example 1 - The Glarus Thrust, Switzerland



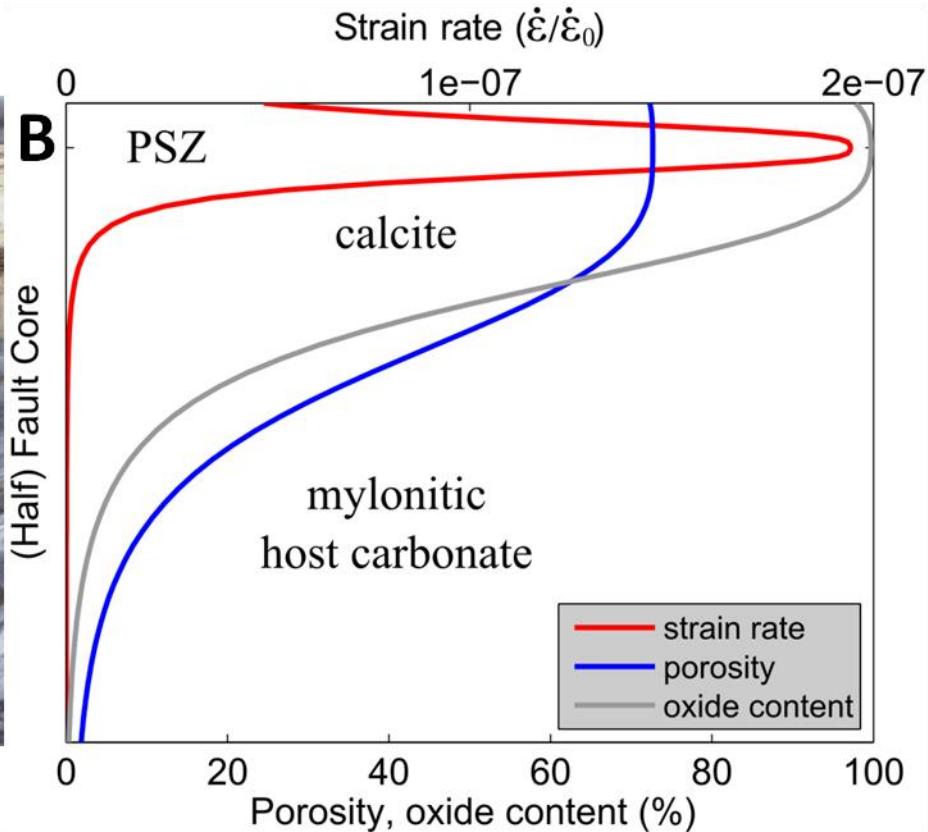
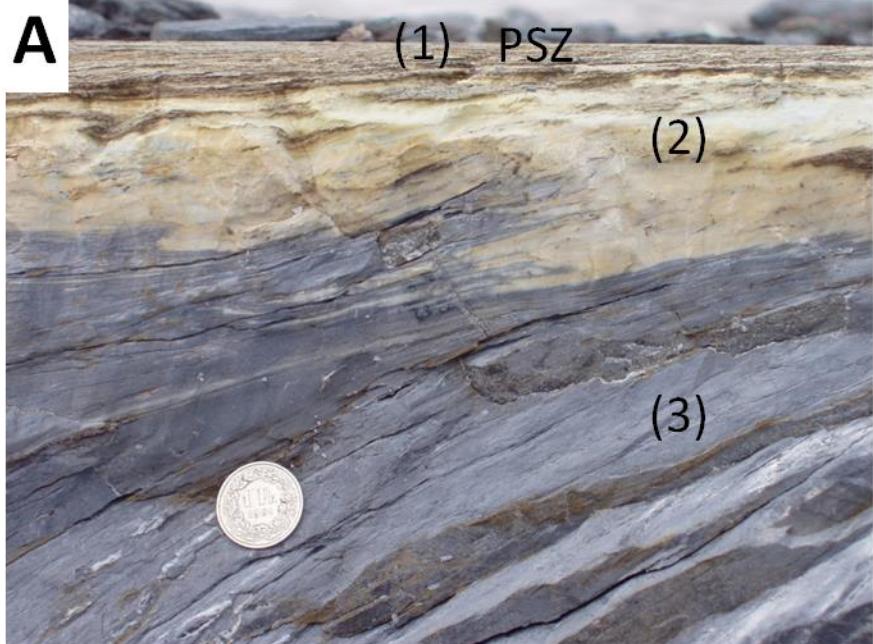
The Glarus thrust – cyclicity



The oscillator



A Glarus pattern



- Calcite as a cause
- Source of fluid explained!